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Surveillance Robot for Unauthorized Areas Using Arduino and Location Mapping

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***Abstract*— This project is designed to measure the distance of any object or obstacle in open areas where measurement becomes difficult by manual means. In particular, the need of monitoring air traffic and the defense borders where a soldier keeps on watching for any intruder from top of the buildings. Ultrasonic means of distance measurement is a convenient method compared to traditional one using measurement scales. This kind of measurement is particularly applicable to inaccessible areas where traditional means cannot be implemented such as high temperature, pressure zones etc. This proposed system uses an ultrasonic module interfaced to Arduino microcontroller.**

***Index Terms*— Ultrasonic sensor; Arduino; Wi-Fi module; distance measurement; Android; 2D mapping.**

I. INTRODUCTION

Cloud Storage is an emerging means of backup widely adopted everywhere. It becomes easier to store, retrieve and modify the data in cloud. There are many ways to measure the distance of any targeted object such as proximity sensors, infrared sensors and ultrasonic sensors [1][4]and so on. Beside the above mentioned sensors there are some other means such as SONAR [3], Sona Switch for measuring long range distances. This project aims to provide a low cost and a simple module for detecting and measuring the distance of the obstacle. So it is desirable to use Ultrasonic sensor and also the visualization is made in the android smartphone which is seen in everyone's pocket. The project concentrates in providing a system that can (1) detect the obstacle or intruder, (2) measure the distance of the position of intruder, (3) displays the distance through a smart application in the android mobile.

From the sensor the ultrasonic waves of 40 kHz frequency is passed through air and is made to hit any obstacle if present. The transmitted waves are reflected back from the object and received by the transducer again. The total time sending the waves from the sensor and receiving it back is calculated by considering the velocity of sound waves sent by the sensor. Industries have focused on the creation of new systems for mapping and exploration of unknown spaces in order to create advanced guide systems for robots and people affected by disabilities. In particular, the most common applications are related to the exploration of unknown or dangerous spaces that are not accessible to people by a new low-cost system namely ultrasonic radar system (URAS) [1], to blindly map environments by using ultrasonic sensor and displaying the acquired information through an android based device. Robot module, which is a physical support for the independent module and composed of servomotors remotely controlled by an android based Smartphone**.**

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II. SYSTEM DESCRIPTION

The Surveillance robot designed for the purpose of monitoring the areas of dangerous human access has two major modules.

(1) The robot module – consisting of microcontroller, sensor and a servo motor.

(2) User module – android smartphone.

The major component to control the overall functioning of the system is the Arduino microcontroller and the purpose of storage and command for robot is handled by the Wi-Fi module of family ESP 8266.

A. Arduino Uno:

The Uno board is the processing unit in this project and is a basic computer. With the help of analog and digital pins in the controller the sensor and the motor is operated. The use of arduino microcontroller rather than other controllers such as raspberry pi or PIC controllers is because of the ease of programming any of the arduino family boards with the same software which is available as open source. The arduino software Arduino IDE ha inbuilt libraries for various input and output devices. Also the programming is based on C, C++ which makes users feasible to work on the servo motors and sensor at the same time. It works efficiently for this project as it supports various peripherals.

B. Ultrasonic Sensor:

One of the easiest and simple means of measuring the distance is using an ultrasonic sensor. The sensor used in the project is HCSR04 having 4 pins such as

a. Power input – 5V
b. Trigger pin – input pulse
c. Echo pin – to read the echo pulses reflected from the obstacle.
d. Ground.

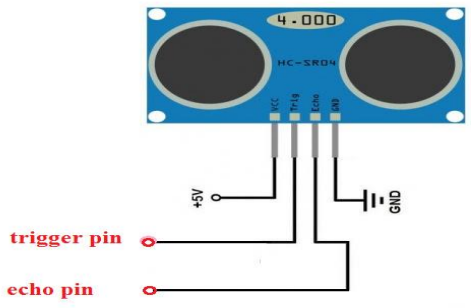

Fig.2.1. Pin Configuration of Ultrasonic Sensor.

The ultrasonic sensor can send its pulses to a distance of about 2 cm to 400 cm. It can operate at a voltage of 5 V DC. The working frequency of HCSR04 is 40 KHZ as it transmits the waves if the trigger input is 10us TTL pulse. When the trigger pulses are sent through air it hits the obstacle and the echo pulse that returns is received by the echo pin. If no echo is received after 38us then it is taken as a null value.

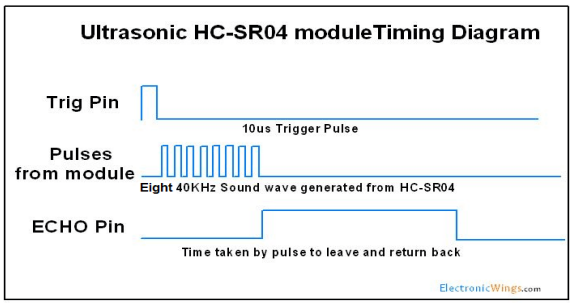

Fig.2.2. Timing diagram of HCSR04

C. Servo motor:

Servo motors are motors that are designed to work sophisticatedly to measure the angular position. This is controlled by the arduino microcontroller. The motor used in this project is SG90 which has 3 leads. The servo motor is an assembly of four units: a normal DC motor, a gear reduction unit, a position-sensing device and a control circuit. SG90 requires a supply voltage of 4.8 V to 6 V and has three position determining pulses namely maximum position, minimum position and the neutral position.

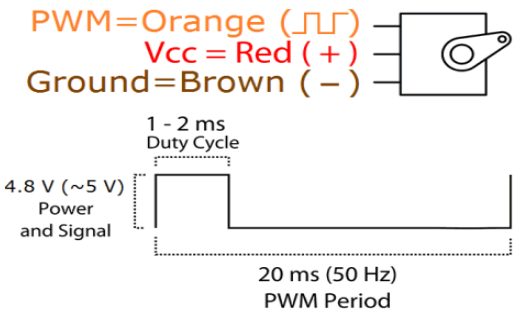

Fig.2.3. Input pulse for Servomotor

D. Wi-Fi Module:

ESP 8266 is a module that is used for many of the Internet of Things applications. The operating voltage of this module is 3 V and can withstand a maximum of 3.6 V. The servo motor is connected to the arduino and is made to work according to the duty cycle of the input pulses sent from the controller. The purpose of the motor in this project is to move the direction of the sensor to various degrees from 0 to 180 to sense the intruder or obstacle in the circumference of 180 degrees. This is because the servo motor can turn upto 180 degrees.

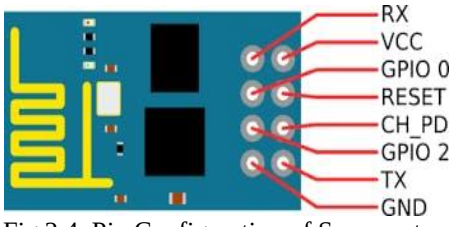

Fig.2.4. Pin Configuration of Servomotor.

In total there are 8 pins in ESP 8266 module and each one is designed to do a specified function. They are assigned with appropriate function

a. VCC and GND – powering pins.
b. Rx and Tx – communication to/from arduino
c. GPIO 0 & GPIO 1 – input/output operation from arduino
d. CH_PD – chip enable
e. RESET.

The module supports 802.11 b/g/n protocol and has 2.4 GHz band. The major purpose of this module is to enable the control of robot module from long distance by the user through the user interface provided by the application. The information regarding the obstacle or the intruder from the fixed robot can be stored in the cloud for future use. From survey the previous methods specify the control of robot through Bluetooth [1] [11] is of limited range. But this project makes use of large area covering Wireless Fidelity counting over 500 meters.

III. METHODOLOGY

The system functionality can be explained with the block diagram and flow chart shown in the fig.5 and fig.6.

a. Block diagram:

In this project the arduino plays the major role in controlling all the other components such as the sensor, servomotor and the Wi-Fi module. Thus arduino is the core of the surveillance robot. The sensor which detects the obstacle is connected to the analog pins 2 and 4 in the microcontroller. The servo motor is interfaced to the pin 8 and the connections of ESP 8266 is through inter connecting the Tx and Rx of arduino to ESP 8266. The basic connections of the system is understood with the help of block diagram

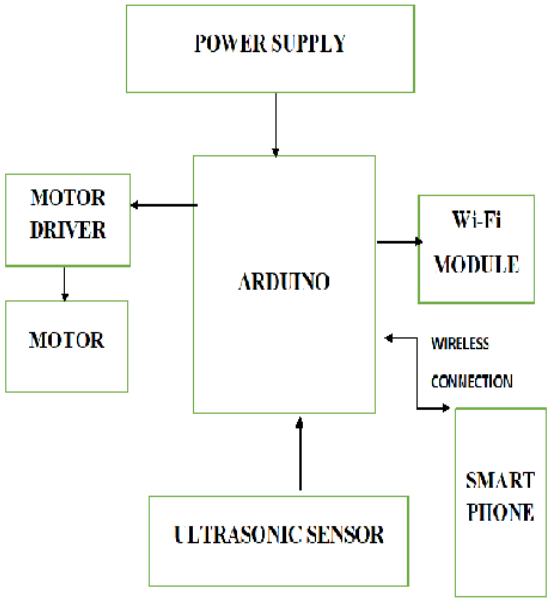

Fig.3.1. Block diagram of Surveillance robot

The power supply used here is 230 V AC supply with the adapter connected to arduino. The analog input peripherals provide connection to the ultrasonic sensor and the servo motor. The motor cannot be driven by the digital output from arduino hence a driver circuit is used. The devices that are

connected to the microcontroller can take the supply voltage from arduino and can effectively operate.

b. Flow chart:

The sensor as soon as the power to arduino is turned on it starts sending the ultrasonic pulses of 40 KHz frequency. The waves as they travel through the air medium hits on any obstacles if present. If there is no obstacle the robot is instructed to change its angle to see for obstacles the other direction.

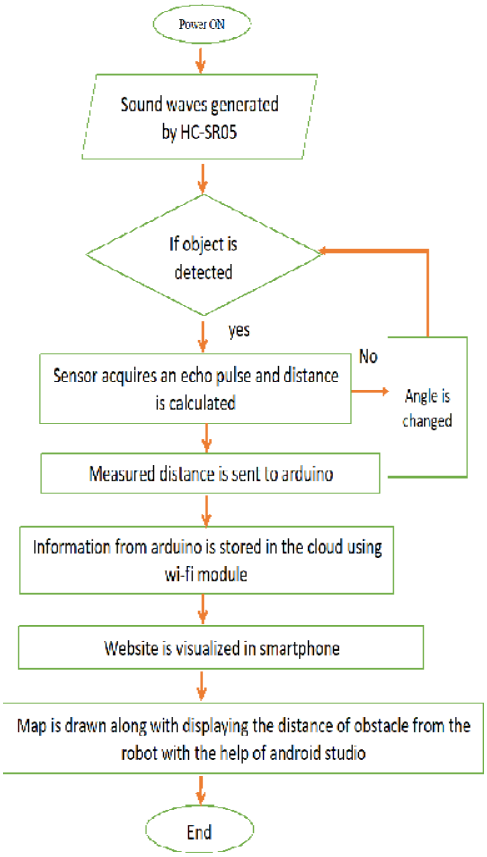

Fig.3.2. Flow of robot operation

As soon as the intruder or the obstacle is detected the distance is calculated with the time period of the received echo pulse.

Distance in meters = velocity of sound * time

Where the velocity of sound is given as 341ms.

This value of distance is sent again to the arduino and is imported to the cloud by ESP 8266. At the same time the distance is mapped in the application running in android smartphone providing some buttons for selecting the angle to turn the robot. Besides showing the 2D map [2] of the detected obstacle the application is programmed to indicate the distance in a tab along with a drop box to select the required angle to turn the robot.

IV. TESTING AND RESULTS

The system was tested in two cases – with near obstacle and a far one. The minimum range of the ultrasonic operation was found to be 5 cm and the maximum range was 250 cm. The experiment was conducted in open air environment and the robot was working effectively in detecting the presence of the obstacle. The surveillance robot was tested independently and found to provide the expected results.

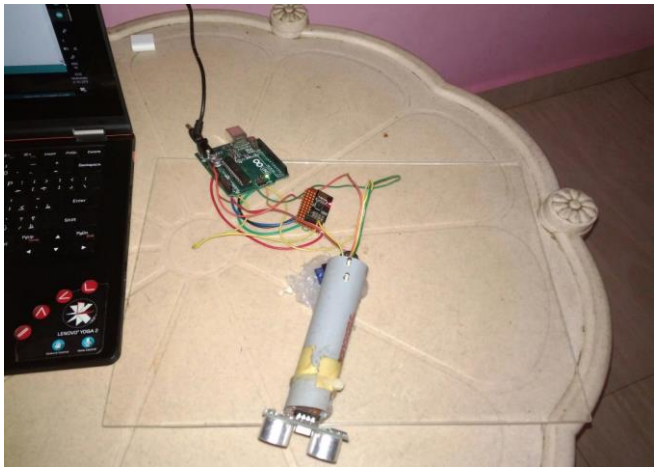

Fig.4.1. Top view of experimental setup

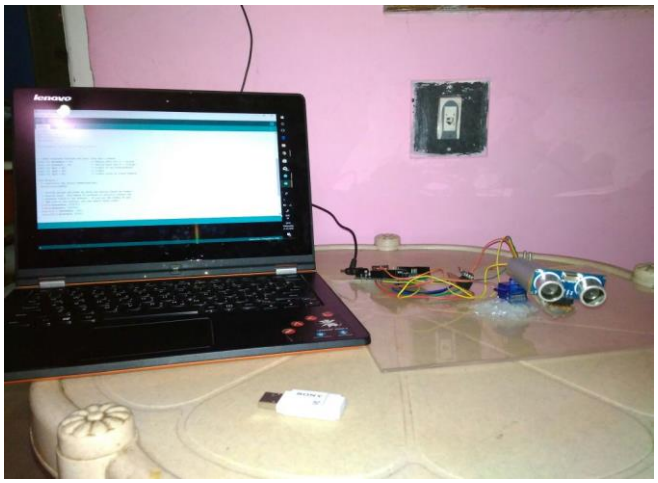

Fig.4.2. Front view of the experimental setup

The application that runs in the android smartphone is configured with no security and anyone can access it. The2D view of the application is constructed with the help of the Android Studio SDK and it appears to be in the form of concentric circles. In the circles the distance is indicted with an yellow line marching towards the obstacle from the origin. The degrees at which the distance is mapped is also indicated at the circumferences of the semi-circle. The button for changing the angle is provided at the bottom of the semi-circle.

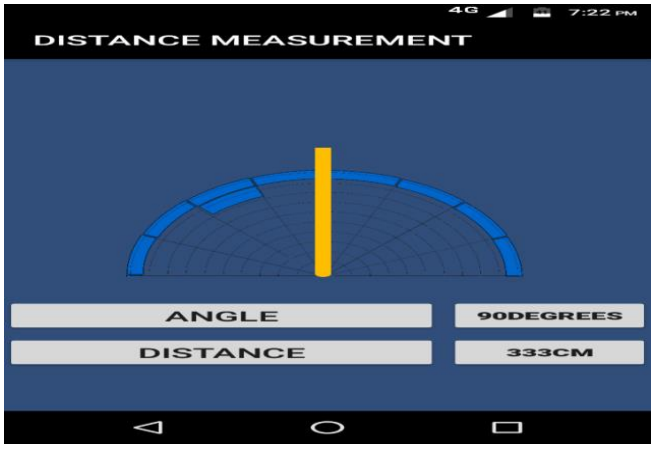

Fig.4.3. Screenshot of the Android application

V. CONCLUSION

This paper presents an overall function of a robot than can replace manual work in monitoring open environments or the areas where the surveillance is not possible for humans. The results have been analysed and is found to be satisfactory. In future the robot can be manipulated to measure a wide range of distance along with extending the surveillance to 360 degrees.

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